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MORPHOLOGY AND BIOLOGY OF THE AUSTRALIAN TREE FROG *LITORIA PEARSONIANA* (COPLAND) (ANURA: HYLIDAE)

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Summary

MCDONALD, K. R. & DAVIES, M. (1990) Morphology and biology of the Australian tree frog *Litoria pearsoniana* (Copland) (Anura: Hylidae). *Trans. R. Soc. S. Aust.* 114(3), 145–156, 30 November, 1990.

Litoria pearsoniana (Copland) is a small, polymorphic tree frog found in northeastern NSW and southeastern Qld at elevated altitudes. Morphometric data, colour variation and osteological data are provided together with observations on large winter aggregations of the species, temperature regulation and behaviour. The call and tadpole are described and a possible decline in populations is reported.

KEY WORDS: *Litoria pearsoniana*, tree frog, morphology, biology, advertisement call, osteology, larval development, winter hibernaculum, distribution.

Introduction

Litoria pearsoniana (Copland) is a small hylid frog occurring on the eastern seaboard of Australia. It is closely related to *Litoria citropa* (Duméril & Bibron), *L. subglandulosa* Tyler & Anstis, *L. piperata* Tyler & Davies and *L. phyllochroa* (Günther) with which it forms the *L. citropa* species group of Tyler & Davies (1978).

In the original description Copland (1960) compared *L. pearsoniana* with *L. gracilenta*, but not with more closely allied species. Moore (1961), Cogger (1975) and Cogger, Cameron & Cogger (1983) considered it to be a synonym of *L. phyllochroa* although these latter authors did not justify their conclusion. Frost (1985) recognised the species on the basis of chromosome data presented by King (1980) and differences in call indicated by Barker & Grigg (1977).

The name *L. barringtonensis* (Copland) has been applied by Ingram & Covacevich (1981) and Czechura (1983) to species here recognised as *L. pearsoniana*. However, none of these authors provided justification for the name change. The types of *L. phyllochroa barringtonensis* are subadult, and a conclusion as to their status was considered to be impossible by Tyler & Davies (1985) in the absence of topotypic material reliably identified as *L. pearsoniana*, *L. phyllochroa* or *L. piperata*.

Few data have been published on the biology and habitat preferences of *L. pearsoniana* other than those provided in the description by Copland (1960), Straughan (1966)[1] and Barker & Grigg (1977), despite the species' abundance throughout its range during this study.

Here we report data on the morphology, habitat, biology and distribution of the species, collected during Queensland National Parks and Wildlife Surveys within the Moreton region of Queensland, and in particular the Kilcoy Shire (McEvoy *et al.* 1979).

Materials and methods

The specimens reported here are lodged in the following collections: Queensland Museum, Brisbane (QM); South Australian Museum, Adelaide (SAM); University of Adelaide Zoology Department (UAZ); Queensland National Parks and Wildlife Service (QNPWS).

Animals were measured with dial calipers measuring to .01 mm.

Methods of measurement of adults follow Tyler (1968). The following measurements were taken: snout-vent length (S-V); tibia length (TL); head width (HW); head length (HL); eye to naris distance (E–N); internarial span (IN). Measurements are expressed in mm, as mean ($\bar{x}$) ± standard deviation.

Larvae were staged according to Gosner (1960). The following measurements (in mm) were taken using dial calipers measuring to .05 mm or an eyepiece micrometer: total length (TL), body length (BL), maximum body width (MBW), body width at eyes (EBW), maximum body depth (BD), snout to eye (SE), snout to naris (SN), eye to naris (EN), snout to spiracular opening (SS), internarial

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[1] Straughan, I. R. An analysis of species recognition and species isolation in certain Queensland frogs. Ph.D. thesis, University of Qld. Unpubl.

distance (IN), interorbital distance (EE), width of outer eye surface (OE), eye diameter (E), pupil diameter (P), narial diameters (ND), transverse oral disc diameter (TDD), basal tail muscle height (BTMH), basal tail muscle width (BTMW), maximum dorsal fin height (DF), maximum ventral fin height (VF), distance from maximum dorsal fin height to body terminus (BDF), tail muscle height at maximum dorsal fin height (TMD), distance from maximum ventral fin height to body terminus (BVF), tail muscle height at maximum ventral fin height (TMV).

Calls were recorded on a Uher 4000 Report portable reel-to-reel tape recorder at a tape speed of 19 cm/sec and a Grampian DP_4 microphone. Calls were analysed on a DSP 5000 digital Sona-Graph (Kay Elemetrics) with playback on a Revox B7711 stereo tape recorder. Frequency responses of all audio-electronic components are close to linear with the relevant frequency range (1000–5000 KHz). The built-in set up No. 10 was used for analysis on the Sona-Graph.

Classification of vegetation follows Webb (1959). Observations on aggregating frogs were made from August 1976-September 1978. Cloacal temperatures were taken with a Schultheis rapid reading thermometer. Specimens were handled by the hind limbs with a gloved hand to minimize heat transfer. Humidity was determined using a Zeal hygrometer at the opening of the crack occupied by overwintering frogs, whilst air, water and microhabitat temperatures were measured to the nearest 0.2°C using Schultheis thermometers. Thermometers were calibrated regularly.

Data were analysed using two-tailed Student t-test and regression equations.

Illustrations were drawn using a Wild M8 stereo dissecting microscope and an attached camera lucida.

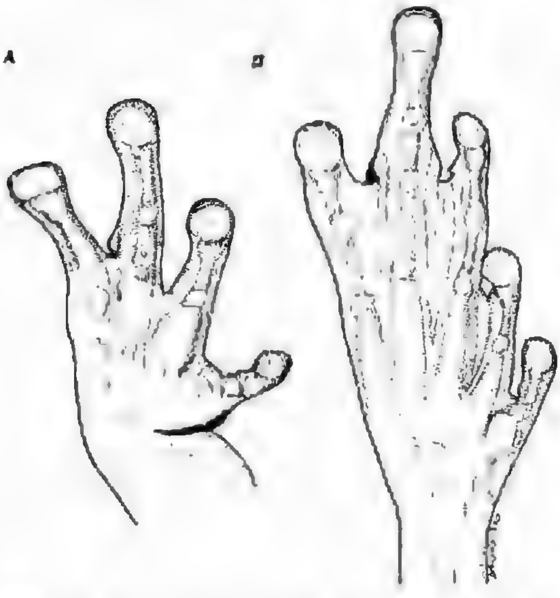

Fig. 1. A, Palmar view of hand and B, plantar view of foot of *Litoria pearsoniana* (UAZ reference collection).

Results

Litoria pearsoniana (Copland, 1961)
FIGS 1–3, 7–12

Hyla pearsoni Copland, 1960 p. 154
Hyla pearsoniana Copland, 1961 p. 168
Litoria pearsoni: Tyler 1971 p. 354
Litoria pearsoniana: Barker & Grigg 1977 p. 56
Litoria barringtonensis: Ingram & Covacevich 1981 p. 299

Definition: Small green tree frogs (♂♂ 24–29 mm, ♀♀ 30–37 mm) with well-developed lateral stripe from naris to flank, brown tympanum, large finger and toe discs, basally webbed fingers, extensively webbed toes, slightly developed submental gland.

External morphology

Only variations from the original description of Copland (1960) are provided here.

S–V of a sample of 20 adult males from the Conondale Ranges ranged from 24.4–29.1 mm ($\bar{x}$ = 23.2 ± 1.3) and S–V of 20 gravid females ranged from 30.5–35.8 mm ($\bar{x}$ = 32.1 ± 1.6). The largest *L. pearsoniana* examined was a female of 37.1 mm S–V.

The head is deep, flattened dorsally, rounded in dorsal view and broader than long (HL/HW, females 0.89–1.00, $\bar{x}$ = 0.95 ± 0.03; males 0.92–0.98, $\bar{x}$ = 0.95 ± 0.02). Eye to naris distance is consistently greater than internarial span (E–N/IN, females 1.24–1.52, $\bar{x}$ = 1.41 ± 0.08; males 1.22–1.52, $\bar{x}$ = 1.38 ± 0.09).

The legs are moderately long (TL/S–V, females 0.49–0.56, $\bar{x}$ = 0.53 ± 0.22; males 0.51–0.55, $\bar{x}$ = 0.53 ± 0.01). Webbing between the toes is extensive (Fig. 1), reaching the subarticular tubercle at the base of the penultimate phalanx of toe IV. The fingers are long and slender with large terminal discs and a trace of webbing between the second and third and third and fourth fingers (Fig. 1). A rudimentary submental gland is present.

The colour is highly variable within the species. The dorsum of live adults varies. The following colours were observed: dark brown, brown with green suffusions, yellowish brown with green suffusions, brown and green and completely green, all with or without black spots or reticulations. A brown canthal stripe extends from the naris through

Fig. 2. *Litoria pearsoniana* in life (Conondale Ranges).

the eye and tympanum along the flank to the mid-body (Fig. 2). It is barely discernible in brown specimens.

The anterior and posterior surfaces of the hindlimbs vary from yellowish tan to brick red and can change in an individual over a short period of time. The tympanum is brown merging with the canthal stripe in all the specimens examined. A white upper lip stripe is sometimes present. The iris is golden or bronze. The ventral surface is cream.

Coloration can vary seasonally. Individuals examined from a winter hibernaculum had all of the dorsal colour variation described above. During September when the winter aggregation in the hibernaculum was breaking up, some individuals were brown anteriorly and predominantly mottled green on the posterior half of the dorsal surface and on the legs. In January, these dual coloured frogs were not in evidence. Individuals were either green or brown mottled with green, with all degrees of these colorations occurring. An individual can thus vary from brown to brown and green mottling to predominantly green. Black spotting occurs on both green and brown animals with similar frequency.

Osteology

(based on UAZ A1034, an adult male, S–V 25.3 mm)

Skull moderately ossified (Fig. 3). Sphenethmoid well-ossified extending between nasals dorsally and between vomers ventrally, overlain dorsolaterally by nasals. Prootic and exoccipital completely fused; exoccipitals separated dorsomedially by calcified plate extending anteriorly to form posterior margin of frontoparietal fontanelle. Crista parotica moderately short and stocky, overlain laterally by poorly expanded otic ramus of squamosal. Frontoparietal fontanelle moderately extensive, circular, bordered laterally by poorly ossified frontoparietals which edge about 60% of length of orbit. Anterior margin of frontoparietal fontanelle formed by sphenethmoid at level of anterior 25% of orbit. Posterior margin at level of prootic. Nasals moderately broad, moderately separated medially with acutely tapering maxillary process not articulating with very poorly developed preorbital process of deep partes faciales of maxillae.

Palatines moderately long, moderately slender and acuminate, terminating on sphenethmoid

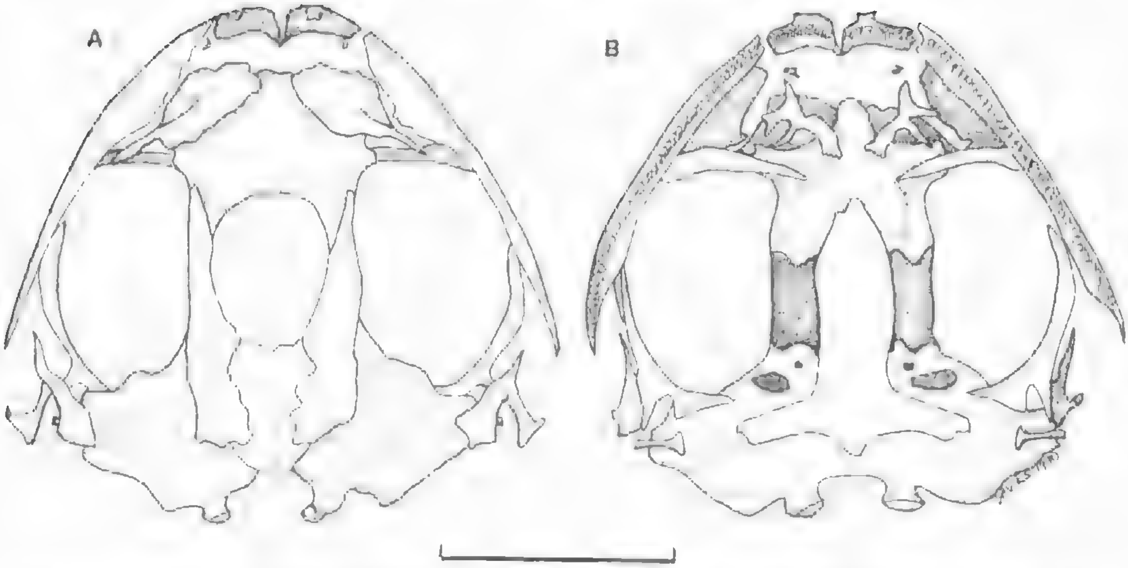

Fig. 3. A, Dorsal and B, ventral views of the skull of *Litoria pearsoniana* (UAZ A1034). Scale bar = 5 mm

between level of dentigerous and posterior alary processes of vomers. Parasphenoid robust with broad cultriform process terminating behind level of palatines. Alary processes moderately slender, short, angled posterolaterally, not overlain by medial rami of pterygoid.

Pterygoid moderately robust; anterior ramus in contact with maxilla about ½-way along length of orbit; posterior ramus short and acuminate; medial ramus expanded distally, in bony contact with prootic. Quadratojugal reduced to base of squamosal. Squamosals moderately robust with short, acuminate zygomatic ramus and poorly expanded otic ramus. Maxilla and premaxilla dentate. Alary processes of premaxillae robust, vertical. Palatine processes of premaxillae short, inclined posteromedially.

Vomers slender, reduced medially (Fig. 3). Short dentigerous processes inclined slightly to midline. Bony columella present. Processus coronoideus of mandible hooked. Pectoral girdle arciferal and robust. Omosternum and xiphisternum present; clavicles slender, curved, minimally separated medially; coracoids robust, moderately separated medially. Bicapitate scapula equal in length to clavicle. Suprascapula about ¼ ossified. Well-developed humeral crest.

Eight procoelous non-imbricate presacral vertebrae. Relative widths of transverse processes III > IV = II > V > VI = VII = VIII. Sacral diapophyses moderately expanded; ilia extend anteriorly to anterior extremity; urostyle bicondylar with dorsal crest extending about ⅔ its length.

Pubis calcified; poorly developed ilial crest. Dorsal prominence moderately developed, more lateral than superior; dorsal protuberance lateral.

Phalangeal formula of hand 3, 3, 4, 4. Terminal phalanges clawed; well-developed bony prepollex. Radiale, os centrale postaxiale and os centrale preaxiale present in carpus.

Phalangeal formula of foot 3, 3, 4, 5, 4; small bony prehallux. Os distale tarsale 1, 2, and 3 present in tarsus.

Variation: A further seven specimens were examined. Variation occurs in the degree of ossification of the sphenethmoid which can extend between and anteriorly to the nasals. The anterolateral edge of the nasal can be in contact with the dorsal edge of the pars facialis. The anterior extremities of the ilia extend about ½-way along the length of the sacral diapophyseal expansion.

Comparison with other species

L. pearsoniana is a member of the *L. citropa* species group of Tyler & Davies (1978, 1985) comprising *L. citropa, L. subglandulosa, L. phyllochroa, L. pearsoniana* and *L. piperata*.

L. peasoniana differs from *L. citropa* and *L. subglandulosa* by its smaller size and by the poorly developed submental gland. From *L. piperata*, *L. pearsoniana* differs by the presence of a conspicuous canthal stripe (faint and narrow in *L. piperata)* and by the absence of a conspicuous anteromedial flange on the otic ramus of the squamosal and greater ossification of the vomers.

L. pearsoniana can be separated from *L. phyllochroa* by having a brown tympanum (green in *L. phyllochroa).*

Key to members of the Litoria citropa *species group*

1. Submental gland not prominent	3
Submental gland prominent	2
2. Tympanum distinct	*L. citropa*
Tympanum indistinct	*L. subglandulosa*
3. Canthal stripe prominent	5
Canthal stripe indistinct	*L. piperata*
4. Tympanum brown	*L. pearsoniana*
Tympanum green	*L. phyllochroa*

Habitat

Specimens have been observed in rocky mountain streams in closed forest (= rainforest), closed forest with emergent *Eucalyptus* forest, or in thickly vegetated streams adjacent to closed forest, in elevated areas of southeast Queensland, and northeast New South Wales.

Adult behaviour

The macrohabitat was complex notophyll vine forest and sclerophyll vine forest of Webb (1959).

In spring and summer adult male frogs were collected during the day under logs, rocks, rotting leaf litter and moist cavities in the soil immediately adjacent to the water edge. At night males were observed calling from rocks, ferns, grass, dead branches and leaf litter in or near streams. The greatest height above water was approx. 1 m. Dry bulb temperatures taken near calling males were 13.9°C–24.8°C. Calling increased on warm nights during and immediately after rain.

Fig. 4. Bridge girder over Kilcoy Creek, Conondale Ranges. The hibernaculum of *Litoria pearsoniana* was located in the arrowed crack.

In winter *L. pearsoniana* forms aggregations under rocks, in cracks in rocks, in cracks in bridge girders and also in cracks behind waterfalls (G. Czechura pers. comm.). Males and females aggregate together and an aggregation located in cracks between bearers on a bridge at the Kilcoy Creek study site (Fig. 4) was observed in the winters of 1976–1978. A sample of 139 taken on 7 September 1976 had a sex ratio of 1 ♀:4.79 ♂♂.

The cracks between the bridge bearers were 0.6–1.0 cm wide in the front and tapered backwards (Fig. 5). Not all cracks were occupied. All narrow openings other than those in the front of cracks were sealed off with mud from old wasps nests and silt seepage from the top of the bridge. Within the occupied cracks the mud had been pushed to the sides and backs of the cracks.

Each frog adopted a pose similar to that of *L. chloris* illustrated by Tyler (1989 plate 35). All were close together in groups in the cracks and all faced toward the opening. Dorsal and ventral surfaces were in contact with the wood surfaces. The eyes were partially or completely closed when examined *in situ* by torch light. Frogs were very lethargic when disturbed or handled.

In early August 1978, 188 frogs were located in the bearer cracks. The aggregation had formed during May and broke up in September. It partially disbanded in August 1978 when weather conditions were overcast with light rain, but it reformed 24 hrs later when cool, fine weather predominated. The only record of the break up of the aggregation during the three years of the study was on 7 September 1977 (air temperature 13.9°C at 8.50 p.m after the first spring light rain) when some breeding commenced; males were calling at intervals and some females spawned. However most males were not giving the complete diphasic call (Straughan 1966[1]). The aggregation had only partially broken up at this stage but by 7 October 1977 it had completely dispersed and frogs were located during the day in decaying vegetation and under rocks and logs on the water edge.

Relative humidity was high during winter, and readings from close to the cracks during a typical 24 hr period in June 1978 together with ambient temperatures in the cracks, in the water and in the outside air are shown in Fig. 6.

There was no significant difference in body temperature between the sexes ($t = 1.7094$, $df = 86$, $0.05 < p < 0.01$), but the body temperatures

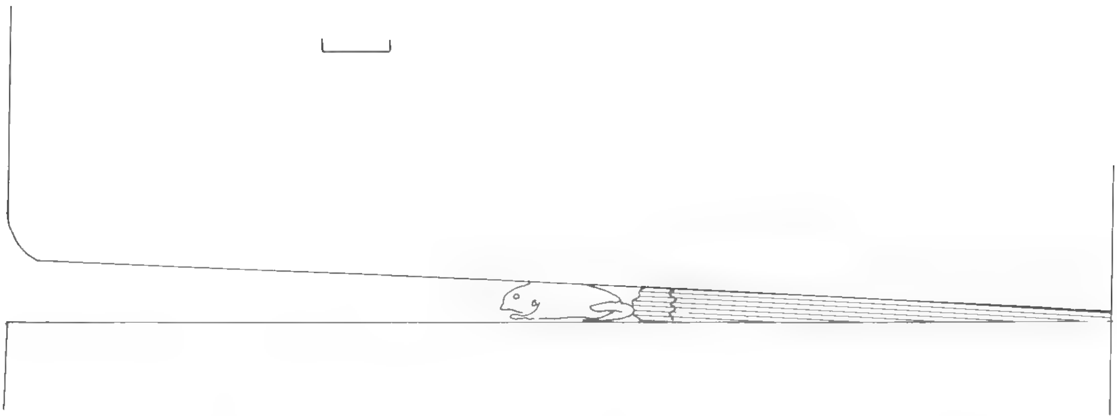

Fig. 5. Dimensions of the crack occupied by a hibernaculum of *Litoria pearsoniana.* Scale bar = 1 cm.

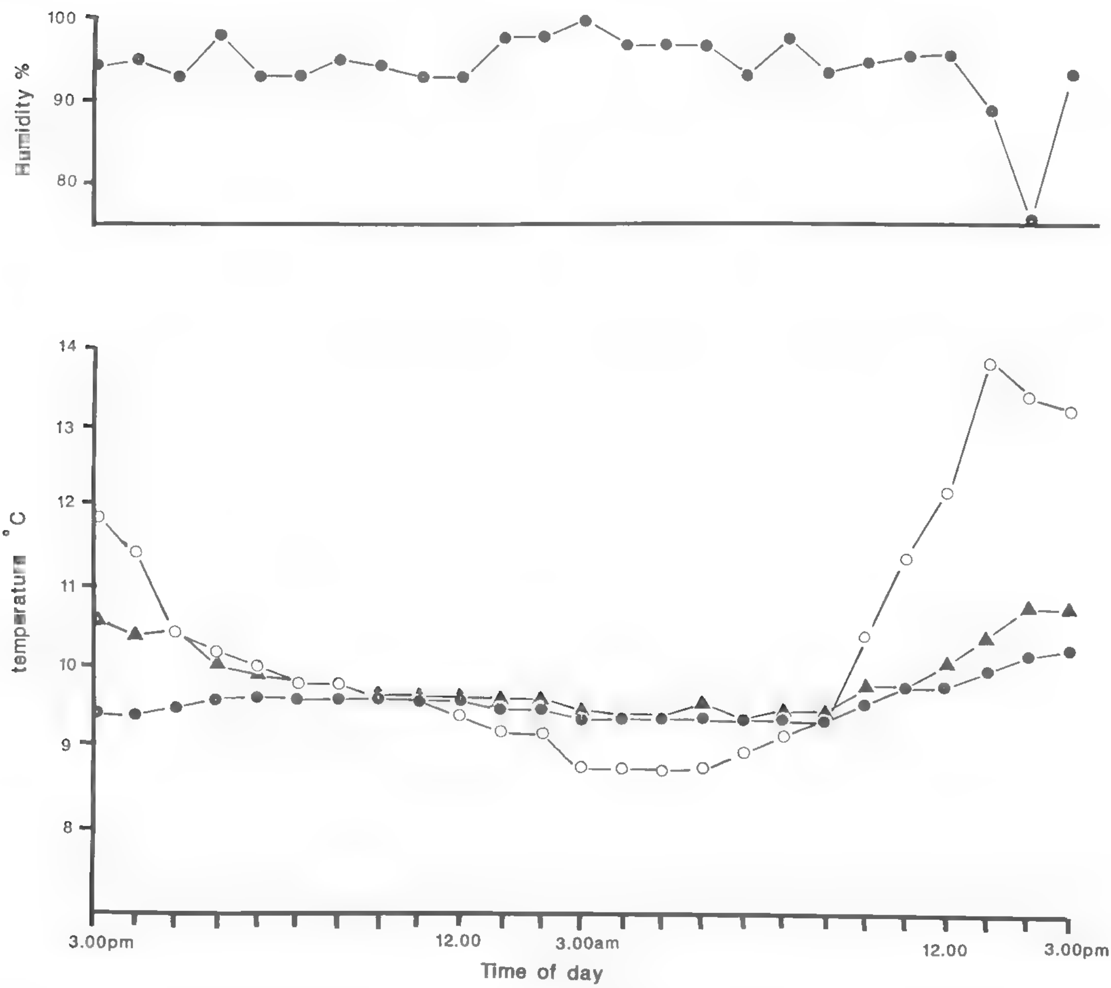

Fig. 6. Relative humidity in the hibernaculum over a 24 hr period in June 1978. Ambient temperature in the crack (closed circle) in the outside air (open circle) and in the water of the stream (triangle) over a 24 hour period in June 1978.

differed between winter and summer ($t = 71.023$, $df = 86$, $p < 0.005$).

Cloacal temperatures of a sample of frogs ($N = 47$, $\bar{x} = 10.12 \pm 0.74$°C) and of ambient air within the cracks and within 5 cm of each frog on 27 June and 26 July 1978 are depicted in Fig. 7A. These winter body temperatures were significantly different from ambient temperature ($t = 4.758$, $df = 45$, $p < 0.005$), the body temperatures being higher on average. There is no significant correlation between body temperature and ambient temperature ($N = 47$, $df = 45$, $r = -0.08864$, $p > 0.10$). Summer body temperatures taken on 17 January 1978 and 23 January 1978 also were significantly different from ambient temperature ($t = 7.82$, $df = 39$, $p < 0.005$). Cloacal temperatures of breeding frogs in summer ($N = 41$, $\bar{x} = 22.74$°C ± 0.93) and ambient air temperature within 3 cm of each frog are shown in Fig. 7B. Again there is no significant correlation between body temperature and ambient temperature ($N = 41$, $df = 39$, $r = -0.18016$, $p > 0.10$).

Temperatures in two cracks lacking frogs did not differ from those in cracks with frogs, but the unoccupied cracks were not true controls as they were of differing dimensions and were not occupied by an equivalent non-living mass similar to the bulk of frogs in the other cracks.

Breeding biology

Males call consistently from early September to February with some spasmodic calling in March and April. Peaks of calling were observed to occur from October to early February, coinciding with the summer rains and the major breeding season.

The call is a diphasic three-note call and can be likened to "Weeek Kuk Kuk". It lasts from 0.8–1.8 seconds (Straughan 1966[1]). The waveform display of an advertisement call taken in the Jimna State Forest at Marumba Creek is shown in Fig. 8. Air temperature at the calling site was 18°C. Call parameters are shown in Table 1. This recording was from a single male sitting on a rock above water, and may not be representative of the calls made in a chorus.

Calling can vary in several ways. A very slow version of the first part of the advertisement call is sometimes heard early in the evening. Sometimes the first part of the call is made by one male and answered by a second by completing the sequence. The duration of these calls and parts of calls is quite variable.

Another call, consisting of the last two notes of the full call repeated several times, was noted in a general chorus recording. We cannot comment further upon the call data in the absence of appropriate temperature measurements.

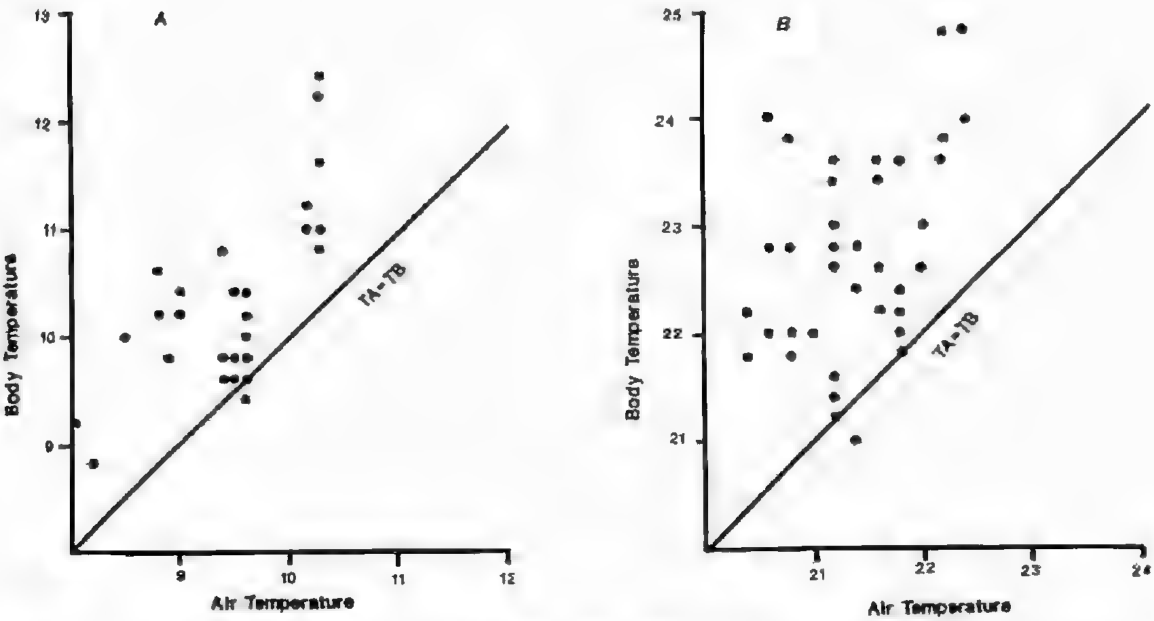

Fig. 7. A. Cloacal temperatures of *Litoria pearsoniana* and ambient temperatures in the crack on 26 June and 27 July 1978. B. Cloacal temperatures of breeding *Litoria pearsoniana* and ambient temperatures in summer.

TABLE 1. *Characteristics of the biphasic call of* Litoria pearsoniana *taken at Marumba Creek, Jimna State Forest, Qld. Air dry temperature at calling site was 18°C.*

	Duration	No. of Pulses	Pulse repetition rate (pulses/sec)	Dominant Frequency (Hz)
Complete call	871.9	–	–	–
Introductory note	262.5	c. 377[1]	432.1	2280, 2680, 3080[2]
First repeated note	84.4	6	67.4	1840
Second repeated note	78.1	6	73.6	1840

[1] Back calculated from note duration and the pulse repetition rate measured from 20 pulses and pulse intervals taken from near the middle of the note.

[2] Three peaks of equal intensity probably representing emphasized size band frequencies generated by the modulating frequency of c. 400 Hz (the pulse repetition rate of the call).

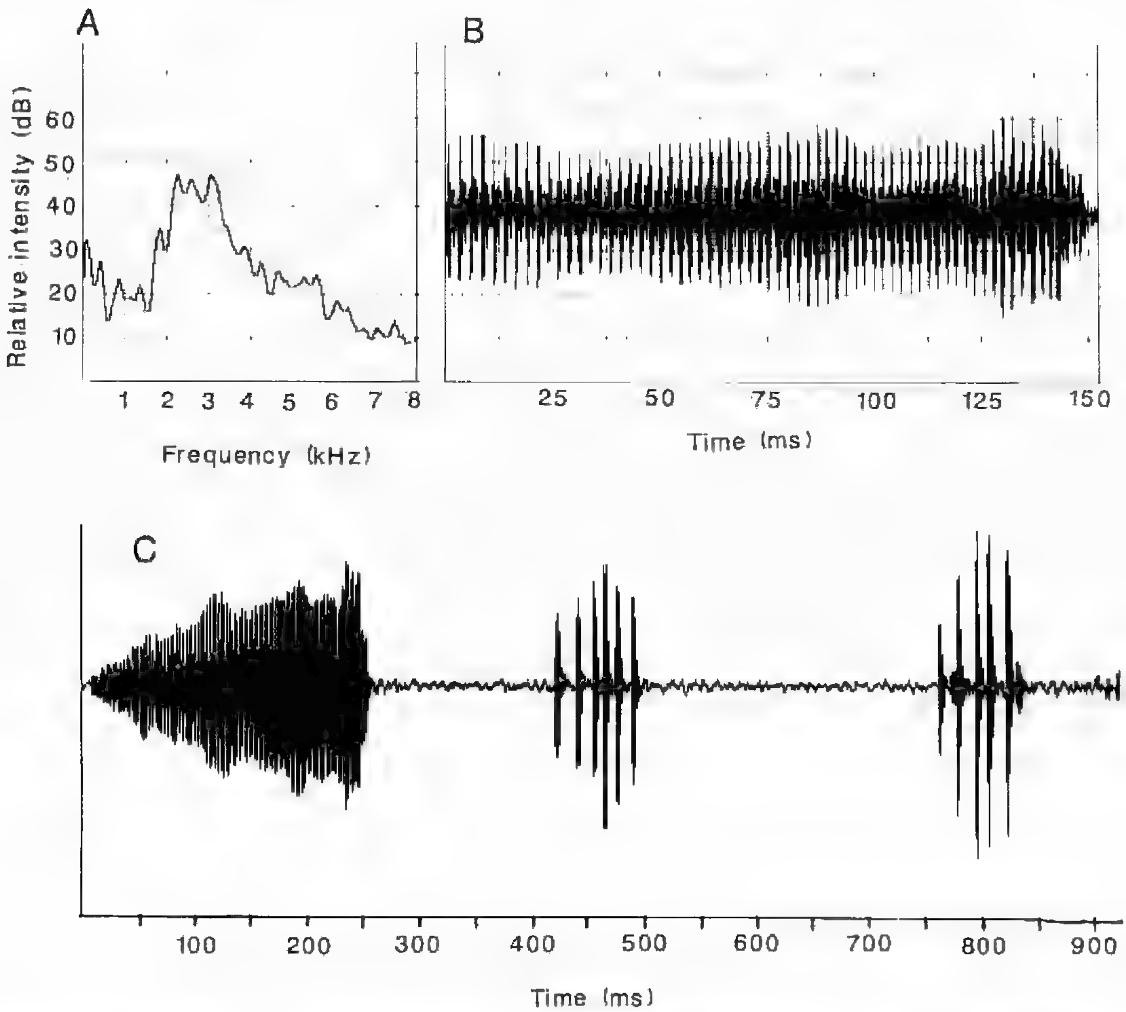

Fig. 8. Waveform display of a calling male *Litoria pearsoniana* at Marumba Creek in the Conondale Ranges. Air temperature at the calling site was 18°C. A = Power spectrum of the introductory note; B = Last segment of introductory note, showing pulses; C = Complete call.

Gravid females were found in the winter hibernaculum from June to August. Ova were at various stages of development with some females having the body cavity fully occupied by eggs.

Litoria pearsoniana was the first species of frog to spawn of the eight species (*Adelotus brevis, Mixophyes fasciolatus, M. iteratus, Rheobatrachus silus, Taudactylus diurnus, Litoria chloris* and *L. lesueuri*) at the study site in Kilcoy Creek. A female which spawned in the field on 15 November 1978 and retained in the laboratory possessed large pigmented ova on 7 December 1978 suggesting a capacity to breed more than once in a season.

Axillary amplexus takes place adjacent to pools connected to or separated from creeks. After amplexus is achieved at or near the male's calling site, the female moves to the water and adopts a position in which about ⅓ of her abdomen and ¼ of that of the male is submerged in the water. When spawning, the female takes a semi-upright position, clasping leaves, rocks or twigs. Spawning usually takes place at night, but has been observed at midday on an overcast day in a shady area of the creek.

Eggs are deposited in still, shallow pools adjacent to, or connected with, the main stream. The greatest depth of water in which ova were deposited was 35 mm. Over the period 1976–1978, spawning commenced in early September, although on one occasion (8 August 1978) breeding occurred earlier in unusally warm conditions with an overcast day and light rain. When cooler weather returned 24 hrs later, the winter hibernaculum reformed until September. The eggs laid on 8 August 1978 were at stage 15 on 17 August 1978 and had not hatched.

Eggs are 1.1–1.3 mm in diameter and are individually capsulated in a clear jelly 3.0–3.5 mm in diameter. They are attached in a mass to twigs, rocks, leaves and vegetation. Eggs have a dark brown animal pole and an off-white vegetal pole. Macroscopically they appear to be black. Silt settles on the jelly capsule in one to two days giving it a grey or brown appearance and concealing the developing embryo. Eggs are laid 5–8 at a time, with occasional groups of up to 12, and can be along twigs and rock surfaces or in clumps on the bottom of a pool. The longest row of eggs measured was 24 cm. Eggs are usually clumped together rather than strung out over such long distances. Spawn clumps comprise 363–732 eggs ($\bar{x}$ = 445, n = 10).

Larvae

Initial development is rapid, neurulation occurring in 2–3 days with hatching occurring 3–5 days after spawning in late September. The eggs hatch at stage 19.

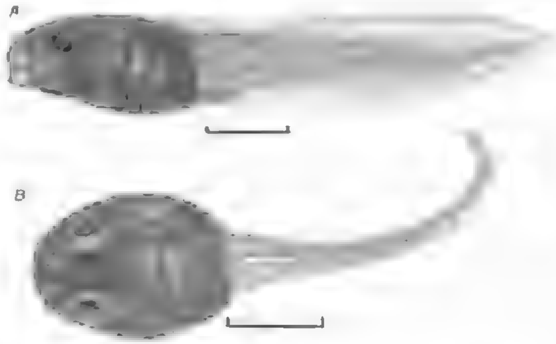

Fig. 9. A, Lateral and B, dorsal views of a tadpole of *Litoria pearsoniana* at Stage 37. Scale bar = 5 mm.

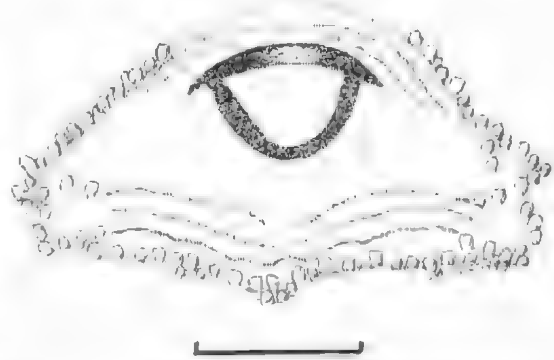

Fig. 10. Oral disc of a tadpole of *Litoria pearsoniana*. Stage 37. Scale bar = 1 mm.

The following description is of a tadpole at stage 37. Body broader than deep with greatest breadth posterior to eyes (Fig. 9). Mouth ventral (Fig. 10) with two upper and three lower rows of labial teeth. The second upper and first lower row have a median gap. Labial papillae surround lateral and posterior margins of mouth.

Dorsal surface of body brown. In later stages of development some specimens have dark spots dorsally.

Spiracle sinistral and ventrolateral (Fig. 10). Anal aperture dextral, opening adjacent to ventral fin. Tail moderately thick, deepest in anterior ⅓. Tip rounded. Neuromasts of lateral line lightly blotched with brown. Fins transparent with clusters of melanophores anteriorly and superiorly. Greatest depth of fin is posteriorly. Ventral surface of body unpigmented. A light golden appearance is characteristic of early stages (i.e. 25–28). Metamorphosis of tadpoles reared at ambient temperature from spawn collected on 27 September

TABLE 2. *Measurements (in mm) of single larvae of* Litoria pearsoniana. *See text for abbreviations.*

Gosner stage	25	37	39	40	41	42
TL	11.52	30.2	25.6	22.6	30.7	27.2
MBW	3.92	7.8	6.16	5.76	8.3	6.0
EBW	3.6	6.2	5.84	5.60	6.9	5.6
P	0.24	0.32	0.48	1.44	0.48	0.56
OE	0.6	1.76	1.76	2.4	1.6	1.6
IN	0.92	1.2	0.96	1.12	1.32	0.96
SE	1.68	2.16	2.08	2.88	2.96	1.68
EN	0.68	1.04	0.96	1.12	1.48	1.28
BTM	0.96	3.52	2.56	3.44	3.6	2.4
DFH	0.96	3.24	1.52	1.52	2.24	1.6
BL	4.44	10.2	8.4	8.12	11.6	9.12
BD	2.32	6.4	3.68	4.4	4.5	3.84
E	0.48	1.28	2.0	1.36	1.36	1.6
EE	1.12	1.44	3.76	2.56	2.8	1.92
ND	1.6×0.4	0.32×0.32	1.6×0.4	0.32×0.24	0.48×0.48	0.24×0.24
SN	0.48	0.96	1.12	1.68	0.88	0.24
SS	3.24	6.64	6.08	6.8	7.8	–
TDD	1.44	2.88	2.56	2.56	3.36	1.44
BTMW	0.72	2.5	1.76	2.56	3.0	2.56
VF	0.72	1.6	1.2	0.64	1.28	1.04
BDF	3.6	12.8	7.84	9.6	8.0	9.6
BVF	3.6	12.8	7.84	9.6	8.0	9.6
TMD	0.4	1.44	1.52	1.12	3.04	1.28
TMV	0.4	1.44	1.52	1.12	3.04	1.28
DVFB	2.28	5.12	3.6	3.44	4.96	3.12

1977 was completed between late December 1977 and early January 1978: a larval life of 2–2½ months.

Mean snout-vent lengths of seven newly-metamorphosed individuals was 9.9 mm (9.3-11.1 mm). Colour was dark brown with a reticulated appearance. No green pigmentation was evident. Newly-metamorphosed individuals were observed in the field in January and February.

Measurements on a developing series of tadpoles are provided in Table 2.

Distribution

Litoria pearsoniana has a distribution in preferred habitat from northeastern N.S.W. (vicinity of Lismore) to the vicinity of Kenilworth, southeast Qld, with an isolated population on Kroombit Tops (Czechura 1986) (Fig. 11). The species is restricted to elevated areas, and has not been located in lower coastal country. Distribution appears to be influenced by the presence of a combination of closed forest or thick vegetation, flowing rocky streams and elevation.

Fig. 11. Distribution of *Litoria pearsoniana* in northern N.S.W. and southeastern Queensland.

Conservation status

At the time of this study (1976–1978), the species was exceptionally abundant (using the criteria of Kirkpatrick & Lavery 1979). However, the species declined at the end of the decade and in December 1983 at the site at which 50 *L. pearsoniana* were collected and checked for colour variation in 1978, only five specimens were seen and heard over a period of 1½ hrs. At this time no confirmed egg masses of *L. pearsoniana* were observed.

Other species of frogs have disappeared from this area including the Gastric brooding frog *Rheobatrachus silus* (Ingram 1983) and the southern day frog *Taudactylus diurnus* (Czechura 1984). We have no further data on abundance of the species and hence are unsure whether the populations have "declined" at other sites along their distribution or of the status of the Conondale Range populations at this time.

Material examined

SAM R17583–5, Warrie N.P., Springbrook; NPWS N15760–2, N15765–7, N15776–81, N17199, N17271–4, N17276, N17278, N17283, N17285–6, N17287–8, N17290–4, N17569–74, N17587, N28004, Conondale N.P., Kilcoy Creek Bridge; N17087, Conondale Ra, Bellthorpe S.F., Sandy Creek; A320, A323, Mt Glorious; A468–471, Twin Falls, Warrie N.P.; A476, Goomoolara Falls, Warrie N.P.; A326, N12012–28, Warrie N.P.; A357, A859–60, Cunningham's Gap N.P.; A352, Girraween N.P.; A758–760, Kondalilla N.P.; N17087, Conondale Ra, Sandy Creek, Bellthorpe S.F.; N17384, 17510, Kundys Hut, Murumba Ck, Jimna S.F.; N17560–3, East Branch; Kilcoy Creek: N17882–4; Murumba Ck, Jimna S.F.; QM J30879, J37645, J40420, J40425, J40428, J40447, Eden Ck Falls, 25 km SE Woodenbong, N.S.W.; J30885, J37637, J40418, J40423–4, Undercliff, N.S.W.; J31478, 11.4 km W Ballina, N.S.W.; J31494, Tweed Plateau, Qld; J35540, Mt Clunie, N.S.W.; J37647–8, J40501, Mackintosh's Rd, nr Woodenbong, N.S.W.; J40419, J40427, Back Creek Rd, Unumgah State Forest (28°25'S, 152°42'E); J46935, Snow Ck, Upper Cooper Ck (28°33'S, 153°23'E). UAZ A87, Mt Nebo; A88–9, Warrie N.P., Springbrook; B421, A1034, A1454–5, Conondale Ra.

Discussion

Litoria pearsoniana is closely related to other members of the *L. citropa* species group as defined by Tyler & Davies (1978, 1985). It shares with these species a number of features including a submental gland and the habit of forming winter aggregations, the choice of breeding sites, the method of egg deposition (Tyler & Anstis 1975; Harrison 1922).

Larvae of *L. pearsoniana* show typical hylid characters in the dorsolateral position of the eye and ventrolateral spiracle. However, the gently rounded tail tip is not typical of hylids (Banks *et al.* 1983). The tooth row formula is typical of many Australian hylid tadpoles (Martin & Watson 1971) and similar to that of *L. citropa* although differing from that species in possessing labial papillae that entirely surround the oral disc. The oral disc of *L. subglandulosa* lacks tooth rows and comprises a funnel of papillae of varying lengths (Tyler & Anstis 1975). Tadpoles of *L. piperata* and *L. phyllochroa* have not been described.

The tadpoles of *L. pearsoniana* have more lotic adaptations in that they are not a high finned necktonic type typical of many Australian hylids (Banks *et al.* 1983).

The call of *L. pearsoniana* is complex and we present the data here to provide a basis for elaboration by other workers.

The observations on overwintering aggregations reported here are the first detailed for an Australian frog species, and suggest that the frogs actively seek appropriate microenvironments in which to overwinter. The full details of site selection remain obscure, but the data indicate that the amplitude of temperature fluctuations and the relative humidity conditions within the microhabitat are important factors. The cracks appear to stabilize both temperature and humidity and the macrohabitat (dense closed forest and associated perennial streams) reduces extreme fluctuations in air temperature and humidity that would be experienced in more open vegetation (Greenslade & Thompson 1981).

Position and posture within the cracks also are important factors in that crowding and maintenance of the limbs against the body reduces exposed surface area and this conserves moisture (Johnson 1971; Tyler 1976, 1989; Heatwole 1963; Heatwole *et al.* 1969).

Body temperatures of inactive frogs in winter were less than 2°C above the temperature in the crack over a 24 hr period. The air within the crack fluctuated through 1°C whilst that outside varied by 5°C. The significant difference between body temperature and ambient air temperature for both summer and winter implies some form of control over body temperature by the frogs.

Populations of species of frog such as *L. pearsoniana* which form winter aggregations can become extremely vulnerable during these periods. Complete or partial destruction of aggregation sites could result in the elimination of a local population whilst destruction of macrohabitat would subject any population remaining to adverse changes in temperature and moisture fluctuations.

The possible decline of the species in the Conondale Ranges is cause for concern as it mirrors declines in other species in that area and elsewhere (Tyler in press). Such declines may be indicative of major environmental problems and as such, deserve careful study.

It should be noted that amongst the material examined in this study were five specimens from Barrington Tops, N.S.W. (QM J34236–9, J34246), the type locality of *Litoria phyllochroa barringtonensis*. These specimens have green tympana and are identified as *L. phyllochroa*. However, in the absence of accompanying call data, we are not prepared to comment further on the status of *L. phyllochroa barringtonensis*.

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